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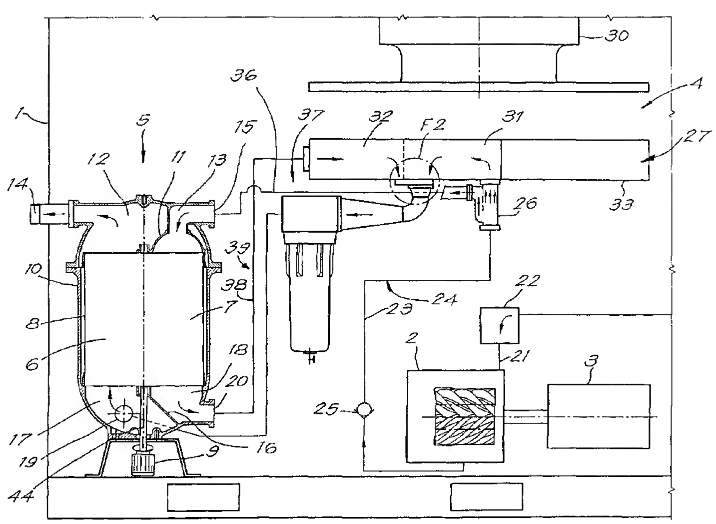
(54) Title: COMPRESSOR INSTALLATION PROVIDED WITH A DRYING DEVICE



(57) Abstract: Compressor installation provided with a drying device (5) having a drying chamber (6) and a regeneration chamber (7) filled with a drying agent which can be regenerated. The compressor installation comprises a compressor element (2) and driving means (3) therefor. The outlet of this compressor element (2) is connected to the drying chamber (6) via a main pipe (24) and over a cooler (4), whereas a secondary pipe (37) extends as of the part of the main pipe (24) which is situated between the compressor element (2) and the cooler (4) to the inlet of the regeneration chamber (7), and a return pipe (39) extends as of the outlet of the latter back to the main pipe (24). This outlet is connected to the main pipe (24) again by means of the return pipe (39), either directly, upstream in relation to the cooler (4), or via a zone (32) of said cooler (4).

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Compressor installation provided with a drying device.

The present invention concerns a compressor installation provided with a drying device having at least one drying chamber and at least one regeneration chamber filled with a drying agent which can be regenerated, which compressor installation comprises at least one compressor element and driving means therefor, whereby the outlet of this compressor element is connected to the drying chamber via a main pipe and over a cooler, whereas a secondary pipe extends as of the part of the main pipe which is situated between the compressor element and the cooler to the inlet of the regeneration chamber, and a return pipe extends as of the outlet of said regeneration chamber back to the main pipe.

A part of the moisture in the compressed gas already condenses in the cooler and is separated in this cooler and/or in a water separator erected behind it. From the cooler, the gas is conducted via the main pipe to the drying chamber, where it is further dried by the drying agent.

While the gas is being dried in the drying chamber, drying agent, which has been used for drying before and which has been saturated, is regenerated by a part of the hot compressed gas which is led to this regeneration chamber via the secondary pipe.

In this regeneration chamber, the above-mentioned part of the gas absorbs the moisture.

Installations are known whereby this gas charged with moisture is released in the environment, but this implies a loss of gas.

That is why most compressor installations of the above-mentioned type contain a second cooler which is erected in a return pipe connecting the outlet of the regeneration chamber to the main pipe. Through this part is led the gas charged with moisture. After the condensation and separation of the moisture in the second cooler, the gas is carried back to the cooled gas which is led into the drying chamber.

Such compressor installations with two separate coolers are known from EP 0.566.180 A, US 3.807.053 A and EP 0.799.635 A.

This second cooler raises the cost price of the installation and occupies extra space. Also, with these known installations, the drying device and this second cooler are erected outside the housing in which the compressor element, the cooler therefor and the motor are erected.

The invention aims to remedy this disadvantage and to provide a compressor installation whereby the portion of gas used for the regeneration is carried back to the main pipe, but which is relatively inexpensive and compact.

This aim is reached according to the invention in that the outlet of the regeneration chamber is connected to the main pipe again via the return pipe, either directly, upstream in relation to the cooler, or via a zone of said cooler.

The portion of compressed gas which has charged itself with moisture in the regeneration chamber, is cooled in the cooler belonging to the compressor element, and no separate cooler is required for the drying installation.

The return pipe can be connected either directly to a zone of the cooler which is separated from the zone over which the main pipe extends, whereby the outlets of both zones open into the main pipe.

In the main pipe, downstream in relation to the cooler, can be provided a jet pump, whereby the return pipe is connected to the vacuous part of this jet pump via a zone of the cooler.

The jet pump can also be provided upstream in relation to the cooler, in the main pipe, whereby the return pipe is then directly connected to the main pipe at said jet pump.

In both cases, the jet pump provides the necessary underpressure to create the secondary flow.

The compressor element and the drying installation are preferably integrated in a single housing, which is easy as

no extra cooler has to be built in to cool the regeneration gas.

In order to better explain the characteristics of the invention, the following preferred embodiments of a compressor installation with a drying device according to the invention are described as an example only without being limitative in any way, with reference to the accompanying drawings, in which:

figure 1 schematically represents a compressor installation with a drying device according to the invention;
figure 2 represents the part which is indicated by F2 in figure 1 to a larger scale;
figure 3 schematically represents a part of a compressor installation with a drying device analogous to that in figure 1, but with reference to another embodiment;
figure 4 schematically represents a part analogous to that in figure 3, but with reference to another embodiment of the invention;
figure 5 schematically represents a part analogous to that in figures 3 and 4, but with reference to yet another embodiment of the invention.

The compressor installation with a drying device represented in figures 1 and 2 comprises a housing 1 in which is mainly provided a compressor element 2; driving means 3, for example a motor, for the compressor element 2; a cooler 4; and a drying device 5.

The drying device 5 is of the type having a drying chamber 6 and a regeneration chamber 7 which are filled with a drying agent which can be regenerated, such as for example silica gel.

The drying chamber 6 and the regeneration 7 form two parts of a vertical drum 8 which is erected in a standing vessel 10 and which can be continuously rotated around its axis by means of a motor 9.

Above the drum 8, the top end of the vessel 10 is divided in two chambers 12 and 13 by means of a partition, whereby the chamber 12 is provided with an outlet 14 and the chamber 13 is provided with an inlet 15.

In an analogous manner, under the drum 8, the lower end of the vessel 10 is divided in two chambers 17 and 18 by a partition 16, which are provided with an inlet 19 and an outlet 20 respectively.

The drum 8 consists of a bundle of vertical pipes which are filled with a drying agent and which let the gas through at the top and at the bottom.

The drying chamber 6 is the part of this drum 8 which is situated between the chambers 12 and 17, whereas the regeneration chamber 7 is the part of the drum 8 which is situated between the chambers 13 and 18.

The direction of flow through the drying chamber 6 and/or the regeneration chamber 7 can be reversed in relation to the direction represented, which implies that the inlet 15 belongs to the chamber 12, and the chamber 13 is now provided with the outlet 14, and/or the chamber 17 is provided with the outlet 20, and the chamber 18 with the inlet 19.

The inlet of the compressor element 2 is connected to an air filter 22 by means of a pipe 21, whereas the outlet of the compressor element 2 is connected to the inlet 19 of the drying device 5 via a pipe 23.

This pipe 23, together with the chamber 17, forms a main pipe 24 for the gas to be dried which is connected to the inlet of the drying chamber 6.

In the pipe 23 are successively erected, in the direction of flow of the gas indicated by the arrows in figure 1, a non-return valve 25, a branch piece 26, the heat exchanger 27 of the above-mentioned cooler 4, a jet pump 28 erected on the outlet of the heat exchanger 27 and a condensed water separator 29.

For the air-cooled machines, the heat exchanger 27 is a sort of cooling radiator opposite to which is erected a fan 30 driven by a motor which is not represented here.

According to a variant, the heat exchanger 27 is a water-cooled exchanger with a common cooling water circuit for its different zones.

In the given example, the heat exchanger 27 is divided in three zones 31, 32 and 33.

The jet pump 28 consists of a nozzle 34 which is connected to the outlet of the zone 31 and which is constricting/widening, and of an ejector pipe 35 erected in the main pipe 24, as is represented in detail in figure 2.

The ejector pipe 35 contains a part which is funnel-shaped and which surrounds the nozzle 34, and a widening part, connected to the preceding part in an arched way, which is connected to the condensed water separator 29.

The above-mentioned branch piece 26, which can be entirely or partly integrated in the heat exchanger 27, just as the nozzle 34, is connected to the inlet of the zone 31 with its main outlet.

The outlet of the zone 32 opens into the funnel-shaped part of the ejector pipe 35, next to the nozzle 34.

A third zone 33 serves for example as an intermediate cooler between the low-pressure stage and the high-pressure stage of a double-stage compressor.

Onto a secondary outlet of the branch piece 26 is connected a pipe 36 which connects this secondary outlet to the inlet 15 of the drying device 5, and which, together with the chamber 13, forms a secondary pipe 37 for gas to be

regenerated which is connected to the inlet of the regeneration chamber 7.

The chamber 18 which is connected to the outlet of this regeneration chamber 7, together with a pipe 38 which is connected to the outlet 20, forms a return pipe 39 for the regeneration gas charged with moisture.

The return pipe 39 is connected to the inlet of the zone 32 of the heat exchanger 27.

During the normal operation of the compressor element 2, gas under pressure is pressed in the main pipe 24.

The gas heated by the compression is subsequently cooled in the heat exchanger 27 of the cooler 4, as a result of which moisture in the gas condenses in the form of mist. The condensed water is then separated in the condensed water separator 29, after which a major part of the remaining moisture in the drying chamber 6 is removed by means of adsorption on the drying agent.

Via the outlet 14, dried gas under pressure leaves the compressor installation.

In the branch piece 26, a portion of the gas which has not been cooled yet is branched off and brought into the regeneration chamber 7 via the secondary pipe 37, where it provides for the regeneration of the drying agent.

The gas of the regeneration chamber 7 charged with moisture is sucked to the pipe 23, thanks to the underpressure prevailing on the outlet of the nozzle 34 and on the inlet of the ejector pipe 35 of the jet pump 28, via the zone 32 of the heat exchanger 27, as indicated in figure 2 by means of an arrow.

The moisture in this portion of gas will condense in the zone 32 and form a mist which, added to the gas which flows out of the zone 31 via the nozzle 34 of the jet pump 28, is separated in the condensed water separator 29 together with the mist-forming condensed water of the latter gas.

Thanks to a continuously rotating movement of the drum 8, the drying agent which is situated between the chambers 12 and 17, and which is thus part of the content of the drying chamber 6, before being saturated, is brought between the chambers 13 and 18, where it is part of the content of the regeneration chamber 7 and can be regenerated again. Reversely, regenerated drying agent ends up between the chambers 12 and 17, so that it forms part of the drying chamber 6 in which the incoming moist air is dried.

What is important is that the cooler 4, which as usual belongs to the compressor element 2, is also used to cool the gas of the regeneration chamber 7. This makes it possible to place all the elements inside the housing 1, without said housing having to be much larger than for the installation without a drying device 5.

The embodiment represented in figure 3 mainly differs from the above-described embodiment in that the design of the jet pump 28 has been changed, and in that the condensed water separator 29 is integrated in the drying device 5, in particular in the chamber 18.

The ejector pipe 35 of the jet pump 28 is constricting/widening. The nozzle 34 which is connected to the outlet of the zone 31 and which is not necessarily constricting/widening, opens with its far end in the widest far end of the constricting part of the ejector pipe 35.

This far end is connected to the outlet of the zone 32 by means of a chamber 40 surrounding the nozzle 34 and with which the ejector pipe 35 is attached to the cooler 4.

The condensed water separator 29 is realised as a coalescence filter in this embodiment and consists of a pipe 41 which is situated inside the chamber 17 and which is connected to the inlet 19 on the one hand, and bends over 90° on the other hand, and opens towards the bottom into a horizontal screen 42 which is erected in this chamber 17, and of a block of filter material 43 sealing the lower end of the part forming the drying chamber 6.

In order to make it possible to erect the condensed water separator 29 in the chamber 17 which, just as the drying chamber 6 is represented on the right-hand side in the vessel 10 instead of on the left-hand side in figure 3, this chamber 17 is larger than in the above-described embodiment.

That is why the drum 8 is no longer driven by the motor 9 by means of an axially situated shaft 44 protruding outside the vessel 10 at the bottom, but by means of a gear wheel 45 which meshes in teeth on the circumference of the lower end of this drum 8.

The operation is analogous to the above-described operation, with this difference that the condensed water of the gas coming from the zone 31 as well as of the gas sucked out of the zone 32 by the jet nozzle pipe 28, is separated at the bottom of the drying device 5 and is discharged through a drain hole 46.

The embodiment represented in figure 4 differs from the embodiment according to figures 1 and 2 in that no jet pump 28 is erected on the outlet of the zone 31 of the heat exchanger 27, but a similar jet pump 28A is provided on the inlet of this zone 31, downstream to the connection of the secondary pipe 37.

In fact, the jet pump 28A is built-in in the branch piece 26. In this branch piece 26 is erected, just past the branch, the nozzle 34 forming a pipe constricting towards the zone 31 of which the wide far end entirely covers the passage. The housing of this branch piece 26 then forms the ejector pipe 35, and the return pipe 39 opens into said branch piece 26 on the outlet of the nozzle 34 of this jet pump 28A.

The heat exchanger 27 in this case no longer has a second zone 32.

Further, the drum 8 is driven in the same manner as in the embodiment according to figure 3, i.e. by means of a gear wheel 45 which is driven by a motor 47 and which meshes in teeth on the circumference of the lower end of this drum 8.

The operation is as described above, with this difference that the gas of the regeneration chamber 7 charged with moisture is first added to the gas of the compressor element 2 again, before being cooled together in the cooler 4.

The embodiment represented in figure 5 differs from the embodiment represented in figure 4 in that the condensed water separator 29 is built-in in the drying device 5 in an analogous manner as in the embodiment represented in figure 3.

Said condensed water separator 29 is designed in the same manner as has been described above in relation to figure 3.

The invention is by no means limited to the above-described embodiments represented in the accompanying drawings; on the contrary, such a compressor installation with a drying device can be made in all sorts of variants while still remaining within the scope of the invention.

Claims.

1. Compressor installation provided with a drying device (5) having at least one drying chamber (6) and at least one regeneration chamber (7) filled with a drying agent which can be regenerated, which compressor installation comprises at least one compressor element (2) and driving means (3) therefor, whereby the outlet of this compressor element (2) is connected to the drying chamber (6) via a main pipe (24) and over a cooler (4), whereas a secondary pipe (37) extends as of the part of the main pipe (24) which is situated between the compressor element (2) and the cooler (4) to the inlet of the regeneration chamber (7), and a return pipe (39) extends as of the outlet of said regeneration chamber (7) back to the main pipe (24), characterised in that the outlet of the regeneration chamber (7) is connected to the main pipe (24) again via the return pipe (39), either directly, upstream in relation to the cooler (4), or via a zone (32) of said cooler (4).

2. Compressor installation provided with a drying device (5) according to claim 1, characterised in that the return pipe (39) is connected to a zone (32) of the cooler (4) which is separated from the zone (31) over which the main pipe (24) extends, whereby the outlets of both zones open into the main pipe (24).

3. Compressor installation provided with a drying device (5) according to claim 2, characterised in that a jet pump

(28) is provided in the main pipe (24), downstream in relation to the cooler (4), and in that the return pipe (39) is connected to the vacuous part of said jet pump (28) via a zone (32) of the cooler (4).

4. Compressor installation provided with a drying device (5) according to claim 3, characterised in that on the outlet of the zone (31) over which the main pipe (24) extends is provided a nozzle (34) of the jet pump (28) opening in an ejector pipe (35), and in that the zone (32) into which the return pipe (39) flows out opens into the ejector pipe (35) next to said nozzle (34).

5. Compressor installation provided with a drying device (5) according to claim 1, characterised in that the return pipe (39) is connected to the main pipe (24) again, upstream in relation to the cooler (4), between the cooler (4) and the connection of the above-mentioned secondary pipe (37) onto the main pipe (24).

6. Compressor installation provided with a drying device (5) according to claim 1, characterised in that, in the main pipe (24), upstream in relation to the cooler (4), is provided a jet pump (28A), and the return pipe (39) is connected directly to the main pipe (24) where this jet pump (28A) is situated.

7. Compressor installation provided with a drying device (5) according to claim 5 and 6, characterised in that the jet pump (28A) contains a nozzle (34) which opens into an ejector pipe (35) provided in the main pipe (24), and in

that the return pipe (39) is situated in this ejector pipe (35) next to or downstream to said nozzle (34).

8. Compressor installation provided with a drying device (5) according to claim 7, characterised in that in the main pipe (24), upstream in relation to the cooler (4), is provided a branch piece (26) onto which the secondary pipe (37) is connected, whereas the nozzle (34) is erected downstream in relation to the gas branch in this branch piece (26), whereby the housing of this branch piece (26) forms the ejector pipe (35).

9. Compressor installation provided with a drying device (5) according to any of the preceding claims, characterised in that the condensed water separator (29) is built-in in the drying device (5).

10. Compressor installation provided with a drying device (5), characterised in that the compressor element (2) and the drying device (5) are integrated in a single housing (1).

11. Compressor installation provided with a drying device (5) according to any of the preceding claims, characterised in that the drying device (5) is of the type containing a standing drum (8) which can be continuously rotated in a vessel (10) by means of driving means, and whereby the top end of the vessel (10) above the drum (8) is divided in at least two chambers (12,13), whereas the lower end of the vessel (10), under the drum (8), is divided in at least two chambers (17,18), and the part of the drum (8) situated

between one top chamber (12) and the chamber (17) underneath it forms the drying chamber (6), whereas the other part of the drum (8) situated between the two other chambers (13 and 18) forms the regeneration chamber (7).

12. Compressor installation provided with a drying device (5) according to claim 11, characterised in that the chamber (12) on one far end of the drying chamber (6) is provided with an outlet (14), and in that the chamber (17) on the other far end of the drying chamber (6) is provided with an inlet (19) and forms part of the main pipe (24), whereas the chamber (13) on one far end of the regeneration chamber (7) is provided with an inlet (15) and forms part of the secondary pipe (36), whereas the chamber (18) on the other far end of the regeneration chamber (7) is provided with an outlet (20) and forms part of the return pipe (38).

13. Compressor installation provided with a drying device (5) according to claims 9 and 12, characterised in that the condensed water separator (29) is built-in in the chamber (17) which is situated on the lower end of the drying chamber (6) and is provided with an inlet (19), and contains a screen (42) into which opens a downward directed pipe connected onto the inlet (19), and a block of filter material (43) on the lower end of the drying chamber (6).

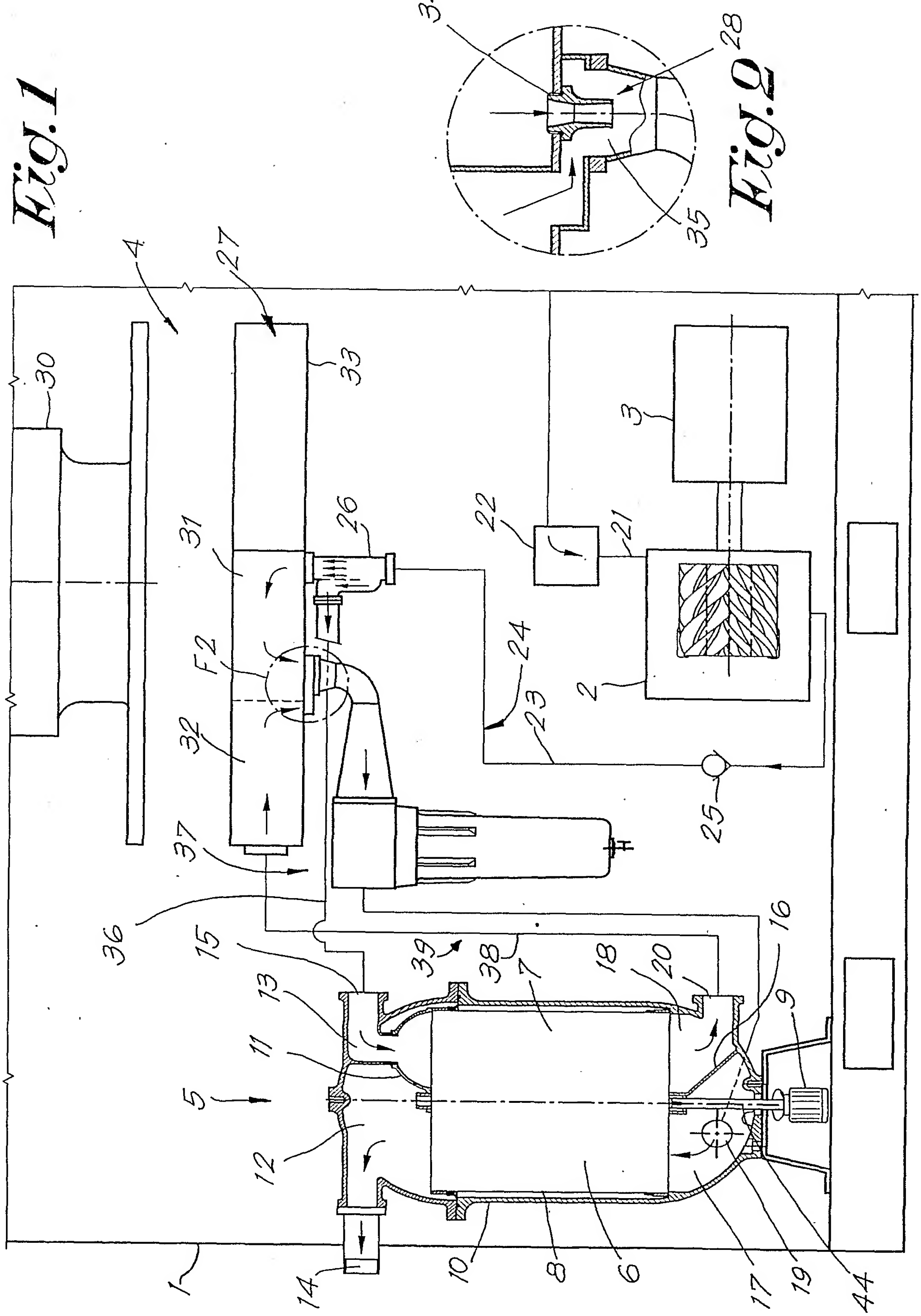
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Fig.1

Fig.2

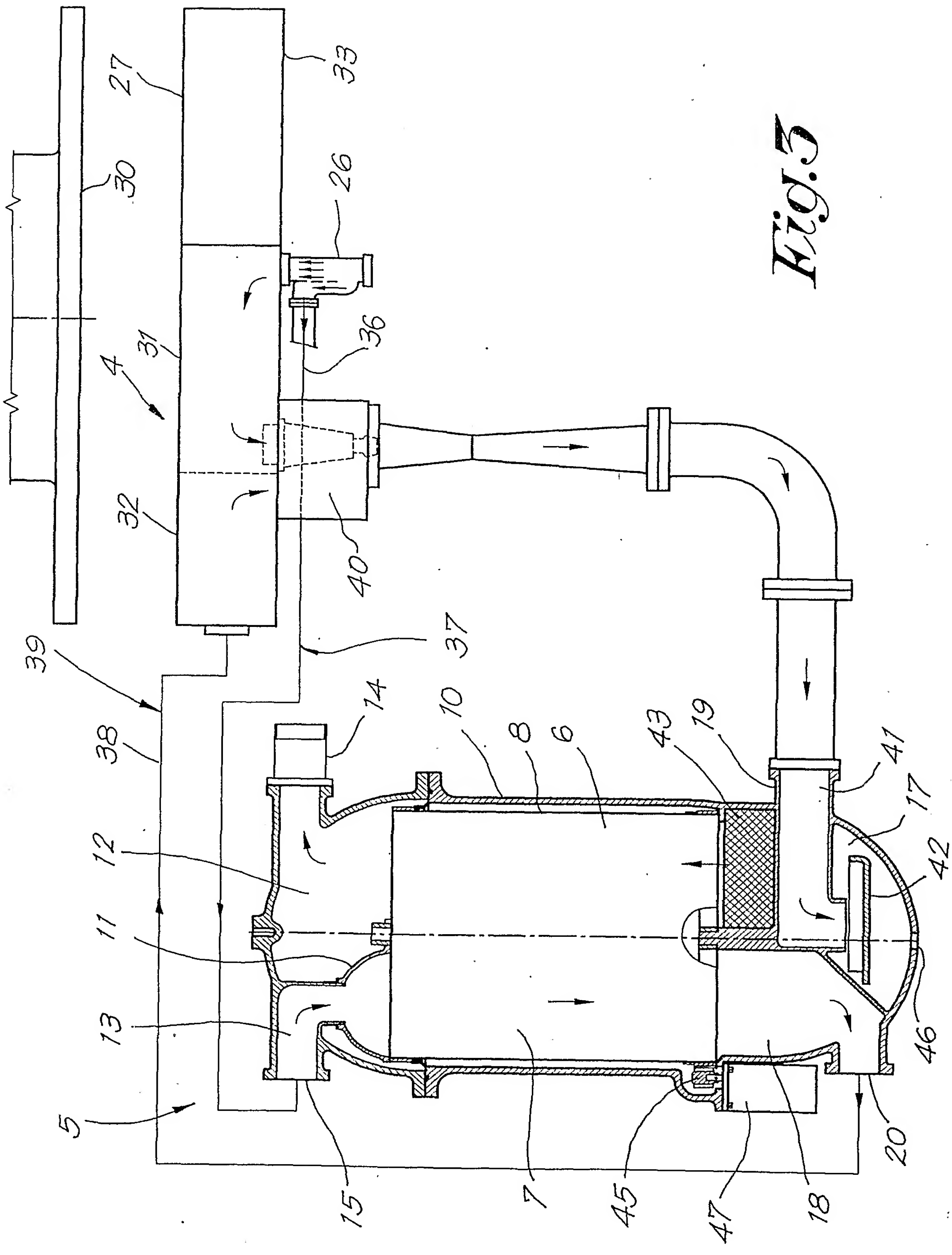
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Fig.3

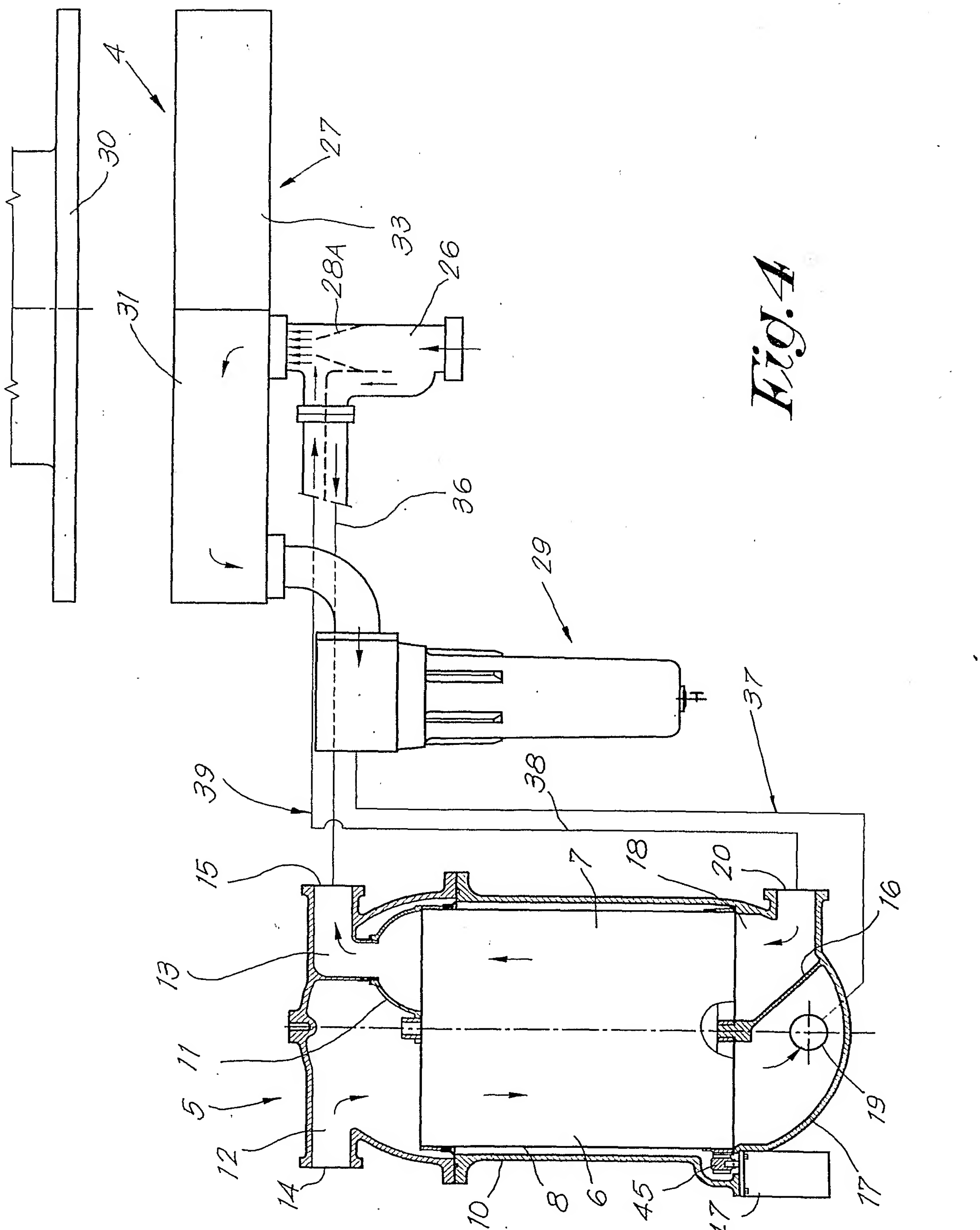
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Fig.4

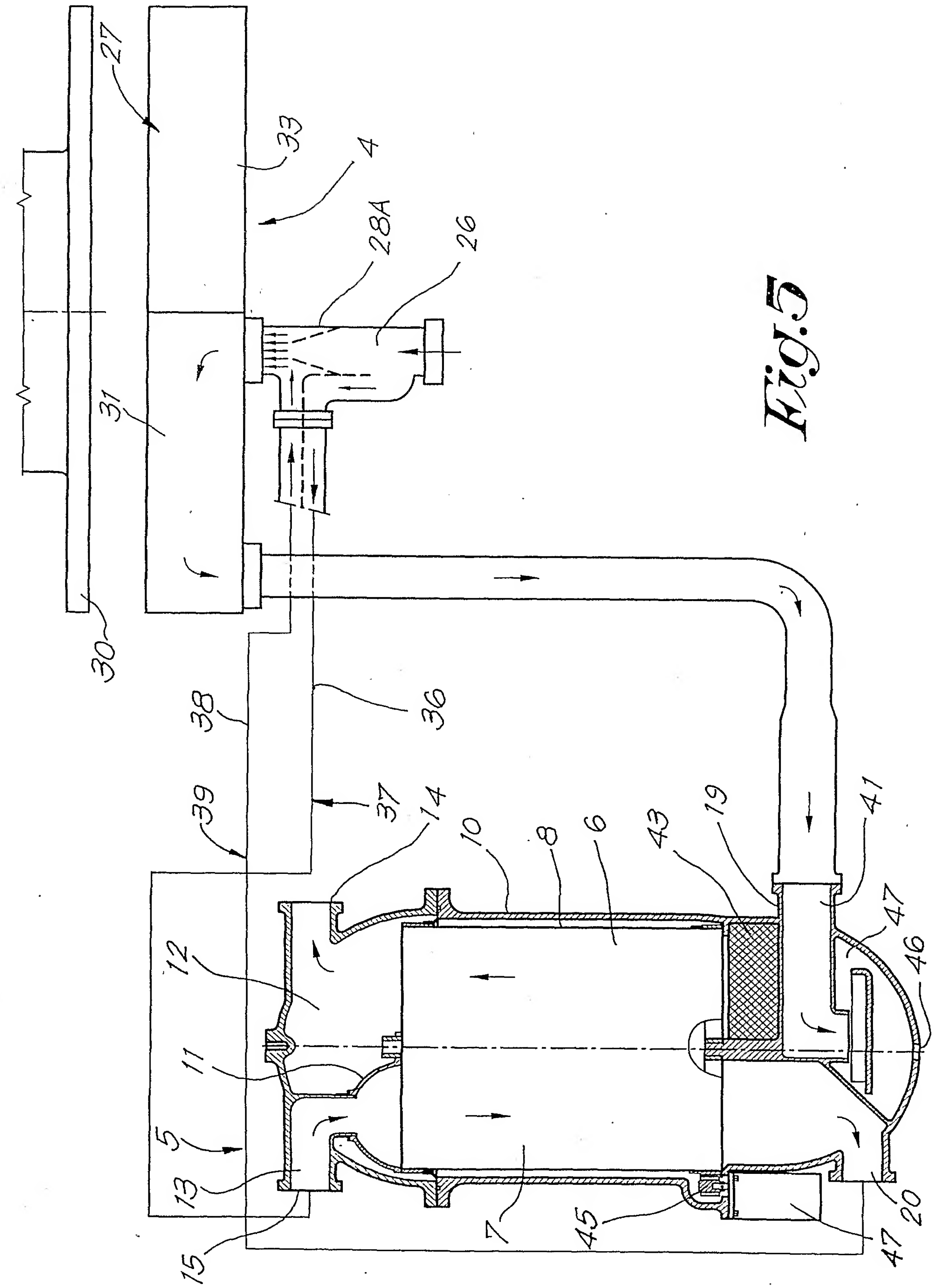
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Fig.5